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RELATIONSHIP OF STAND AGE TO STREAMWATER NITRATE IN NEW HAMPSHIRE

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Abstract: Streamwater nitrate content of six watersheds during spring and summer was apparently related to stand age or age since disturbance. Nitrate concentration averaged 10.3 ppm right after cutting, dropped to a trace in medium-aged stands, and then rose again to a maximum of 4.8 ppm as stands became overmature.

Clearcutting results in accelerated discharge of NO_3– (in addition to other nutrients) into mountain streams in New England (*Pierce et al. 1972*). However, investigations in the White Mountains of New Hampshire (*Pierce et al. 1972*) and investigations in the Bowl Research Natural Area (*Leak 1972*), indicate that NO_3– discharge during the spring-summer period varies considerably among streams draining forest stands that apparently have not been disturbed recently.

The cause of this variation is not known. However, at least two hypotheses exist. Some believe that NO_3– discharge may increase during years when the soil freezes; and there is some evidence from New England watersheds as basis for this point of view. However, soil frost occurs only sporadically in New England watersheds below elevations of 2,500 to 3,000 feet, and the preliminary evidence to date indicates that its effects on nutrient discharge occur during the winter and do not carry over into the spring-summer period (*Hornbeck 1973*). Thus, soil frost does not seem to explain the consistent year-to-year high or low nutrient discharges that characterize a given stream during the spring-summer period.

The other hypothesis is that consistent spring-summer nutrient discharge rates (NO_3– in particular) may be related to stand age. Marks and Bormann (*1972*) suggested that very young fast-growing pioneer stands are effective in reducing nutrient loss from

near the maximum age for the species (nearly 400 years). There is no evidence of any logging. Many trees are dead and dying.

The Bowl stand is recognized as one of the best examples of virgin overmature hardwoods in New Hampshire.

If an average age is determined for each tract by weighting the average age per stand-structure class by the percentage of plots per structure class, the tracts rank in order of increasing age as follows: D.O.C., Davis, Conner, and Underhill, with Greeley and the Bowl about tied for the oldest (table 3).

Streamwater concentrations of NO_3- for the spring-summer period are given in table 4 for the several stand conditions covered by this study. The nutrient data for the Bowl are taken from Leak (*1974*), covering the summer period primarily. The watershed for Tributary 3 is most representative of the Bowl hardwood stand; Tributary 2 also drains part of the stand as well as some mixedwood stands and high-elevation spruce-fir.

The other nutrient data are directly from Pierce *et al.* (*1972*). For comparison, table 4 includes comparable nutrient data from the recent clearcuttings examined by Pierce. Notice that NO_3- discharge is high in recent clearcuttings. It is much lower in the area cutover 30 to 35 years ago. Minimum NO_3- content occurs in even-aged second-growth hardwoods. NO_3- content picks up a little in mature hardwoods. And it becomes noticeably higher in overmature stands, both spruce and hardwoods. This trend is in line with the hypothesis described earlier on the relationship of nutrient release to stand age or age since disturbance.

Table 4.—Comparison of NO_3- streamwater contents (spring-summer period) by stand conditions listed in order of increasing time since disturbance

Stand Conditions	NO_3- ppm Range	NO_3- ppm Average
Recent clearcuttings (*Pierce et al. 1972*)	0.2-28.3	10.3
Cut 30 to 35 years ago—D.O.C.	.4- 5.4	2.3
Second-growth even-aged hardwoods—Davis, Conner	<.1- .9	.15
Old-growth mature hardwoods—Underhill	<.1- 3.6	.8
Overmature spruce—Greeley	.8- 3.5	2.4
Overmature hardwoods—		
Tributary 2	1.7- 2.6	2.2
Tributary 3	3.6- 5.3	4.8

Discussion

The results of this study seem to show a good relationship between streamwater NO_3- during the spring-summer period and stand age or age since disturbance. Beginning with high concentrations of NO_3- right after heavy cutting, the concentrations drop off to a minimum in medium-aged stands and then rise again as the stand goes through maturity into overmaturity.

The study dealt with spring-summer concentrations because of the availability of nutrient data for this period. However, recent evidence indicates that differences among stands in spring-summer concentrations hold up during the winter period when nutrient concentrations and streamwater discharge are highest.

Since completion of this manuscript, we found through personal communication that P. M. Vitousek and W. A. Reiners, of the Department of Biological Sciences at Dartmouth College, Hanover, N.H., have independently uncovered the same relationships. They found that nitrate concentrations throughout the year in streams draining old-aged forest ecosystems on Mt. Moosilauke were consistently higher than those draining successional (intermediate-aged) ecosystems. A manuscript about this, entitled "Ecosystem Succession and Nutrient Retention: A Hypothesis", was submitted in November 1974 to Bioscience.

It is difficult to make an extremely positive statement about the relationship of stand age to nutrient discharge. The subject is complex; many factors other than stand age must influence the nutrient-discharge pattern. Additional research is needed to show how these results relate to the inhibition of nitrification that has been observed in certain climax ecosystems (*Rice and Pancholy 1972*). However, the study certainly has strengthened the hy-

pothesis of a stand-age/nutrient-discharge relationship.

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